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Alternative Metrics for Assessing Knowledge Assets

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Abstract. This paper analyzes two different approaches to assessing the knowledge assets of multiple firms in a given industry. Typically, in evaluating knowledge management (KM) results by measuring intellectual capital (IC), studies in the field have looked specifically at individual firms or a small cluster of organisations. Measuring a large number of firms has proven more of a challenge even though the discipline has some established metrics to do so, principally those using some variation of Tobin's q. In moving such methodologies forward, we look at two variations on Tobin's q for assessing KM requirements in an industry and the relative level of KM success in member firms. We contrast different industries with apparently different KM circumstances, allowing some deeper insights into the strengths and weaknesses of our two metrics. These results will be of interest to those studying KM and IC as they provide guidance in evaluating performance (as well as the need to invest in order to keep up with industry top performers). For the same reason, the results and methodology will inform practitioners taking a strategic approach to knowledge investment, giving them a way to assess relative standing within and across industries. KM strategies can and should differ, and these metrics provide guidance for such decisions.

Keywords: Knowledge management; intellectual capital; strategy; Tobin's q.

1. Background

The fields of knowledge management (KM) and intellectual capital (IC) both have substantial literatures concerning how knowledge assets in firms can vary. The nature of the assets can be different as can organisational circumstances, both suggesting different approaches may be appropriate. Developing around the same time during the 1990s, KM and IC have both received considerable attention from scholars and practitioners. IC largely has to do with identifying and measuring knowledge assets (Bontis, 1999) white KM deals more with how to employ and grow those assets effectively (Grant, 1996; Zack, 1999).

The latter field, KM, adapted the sociology concept of tactiness (Polanyi, 1967) early on, specifically in the key work of Nonaka and Takeuchi (1995). Nonaka and Takeuchi differentiated between tacit and explicit knowledge in an organisation and its individuals. Moreover, their construction of the SECI model broke down the various types of knowledge transfer (socialisation, externalisation, combination, internalisation) based on beginning knowledge (tacit or explicit) and finishing knowledge (tacit or explicit). The natural conclusion, adopted widely and quickly throughout the discipline, was that varying circumstances in terms of the nature of knowledge assets called for different KM approaches. The strategies and applications should vary (Schulz and Jobe, 2001; Boisot, 1995; Choi and Lee, 2003).

From this foundation, much of the work pushing the field forward has included a tendency to identify other variables affecting the nature of the knowledge assets and the nature of the organisation looking to manage those assets. Beyond tacitness, often-studied variables related to the knowledge itself include complexity and specificity (Kogut and Zander, 1992; Zander and Kogut, 1995; McEvily and Chakravarthy, 2002). At the organisational level, variables such as absorptive capacity (Cohen and Levinthal, 1990) and social capital (Nahapiet and Ghoshal, 1998) are commonly observed. All of these combine to increase the potential for dramatically different circumstances concerning KM.

As might be expected, different approaches also grew out of this framework. Related to Nonaka and Takeuchi (1995) and the SECI model noted earlier, scholars and

practitioners began identifying and analysing tools and approaches to growing knowledge, including more tacit-oriented approaches (Brown and Duguid, 1991) and those also incorporating explicit knowledge assets (Thomas *et al.*, 2001; Matson *et al.*, 2003). Essentially, circumstances call for more person-to-person approaches like communities of practice or storytelling at some times while information systems approaches are more appropriate at other times. And the details concerning motivation, trust, and related concepts can also affect the exact application.

In short, there is substantial agreement in the field that the circumstances of KM practice can vary dramatically. As a result, there is also broad agreement on taking a strategic approach to KM, choosing the tools for the job that fit the eclectic circumstances of an organisation and the nature of its knowledge assets. What has not followed, surprisingly, is any real questioning about the level of commitment to KM. Once a system or program is in place, an implicit assumption usually exists that more knowledge identification, development and sharing are always for the best. Very little work has been done on whether the benefit of investment in KM is always for the best, whether it is worth the cost in terms of capital and the time of employees. Over-development can also raise security questions, creating new vulnerabilities without necessarily adding much value.

2. Strategy and Knowledge Management

We believe that exploring a more strategic approach to KM investment is worth some time. Given the dramatically different conditions facing organisations, there is little reason to believe in a one-size-fits-all model of KM. More specifically, differences exist on the national, industry and firm level that can make knowledge development more or less beneficial and that, combined with costs of development and the threat of competitor infiltration, can make significant investment in KM more or less attractive (Rothberg and Erickson, 2005).

This conceptual foundation has been confirmed with empirical results showing that the level of KM development does differ substantially by industry, as do the security vulnerabilities (Erickson and Rothberg, 2012). Employing the Strategic Protection Factor (SPF) approach, Erickson and Rothberg illustrate that there are industries where competitive advantage is highly dependent on generating knowledge while in others, there is very little new or sharable that contributes to such an advantage. Similarly, competitive intelligence activity varies considerably by industry, both in terms of effort and number of firms involved. The main conclusion is that the value of knowledge development and importance of knowledge protection have considerable differences across industries. The different conditions strongly suggest a more strategic approach to knowledge development would be appropriate.

In order to confirm this insight and to give practitioners more specific guidance, however, we need a wider application of appropriate metrics. It is here that IC theory has a part in our discussion. Typically, IC studies will take a bottom-up approach, building a measure of a firm's IC from specific measures of individuals, departments, line item figures like training and education spending, or similar details. As a consequence, the breadth of such work is often limited to a single firm in a case study or a handful of firms in a common industry or geographic area (Marr and Schiuma, 2001; Lev and Radhakrishnan, 2003).

But there is a much wider variety of tools available. Sveiby (2010) lists over forty credible metrics for IC, helpfully dividing them by whether they are bottom-up or top-down as well as by whether they use financial reports or primary data collection. Scholarly reviews of these metrics suggest that the more financial-based techniques do have a role to play in making broader comparisons across companies and industries (Firer and Williams, 2003; Tan *et al.*, 2007). As we will discuss, we see Tobin's q (Tobin and Brainard, 1977) as having the most potential in doing these broad analytics and have used it before in this type of application (Erickson and Rothberg, 2009, 2012).

3. Methodology and Results

This study employs a couple of variations on Tobin's q, allowing us to compare and contrast the variations to assess the best method for comparing knowledge assets across companies and across industries. Although the main idea of Tobin's q has been with us for decades (market capitalisation or value of the company versus replacement value of assets), its actual application is more complicated. Initially, is the relationship studied by subtraction or division? Simply subtracting assets from market cap yields the absolute value of intangible assets, and that can be a valuable number to know. But it can also skew the data by company size. Much larger companies with much larger market capitalisations can easily have much greater levels of intangible assets even if, relatively, they are less efficient or successful in developing such assets.

Consequently, our inclination has always been to use a ratio approach, market cap divided by assets. Firm size is no longer such a biasing factor though complications remain. Initially, the original Tobin's q conceptualisation

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was market cap to replacement value of assets, as noted above. Replacement value, however, can be a hard number to obtain. As a result, a common variation used by researchers is market cap to book value of assets, which can be taken right off a balance sheet. Book value comes from the value of the assets less liabilities (essentially, the level of assets actually owned by the firm). This, again, can be a valuable metric. But for our purposes, it introduces debt into the process. And a fair question to ask is whether debt matters in this application. In developing knowledge assets, the key issue is the intangible value created given the level of physical or financial assets present in the organisation. Does it really matter in assessing IC whether those physical or financial assets are owned or borrowed?

This study looks to add some substance to that question. We employ these two variations of Tobin's q, market capitalisation over book value (Cap/Book) and market capitalisation over asset value (Cap/Asset), to evaluate knowledge development in three industries. This allows comparisons within each industry as well as across industries. From the results, we can compare the pros and cons of the two variations. What are the strengths of each in evaluating firms with similar characteristics within an industry? What are the weaknesses? What are the strengths of each in evaluating IC across industries? And what are the weaknesses?

For this study, we used data from the I/B/E/S database including financial reports from firms listed on North American exchanges. Five years of data, 2005–2009, were used, including all firms within a category reaching $1 billion in revenue in a given year. We looked at three specific industries for this paper. SIC 2834, Pharmaceutical Preparations, is an industry well-known for the value of its IC with a medium level of physical assets (revenue/assets ratio of 0.65). SIC 6020, Commercial Banks, has more limited intangible assets but a high level of tangible financial assets (revenue/assets ratio of 0.07). Most are borrowed, however, so it is an interesting industry given what we are trying to learn from this process. Finally, SIC 2911, Petroleum Refining, has a considerably lower revenue/assets ratio compared to the other two industries, suggesting lower levels of physical assets (revenue/assets ratio of 1.93). Once again, that is a potentially interesting feature in terms of this study.

Results are presented in Tables 1–3, including the firms sorted according to the two different measures. For purposes of analysis, an index centred at 1.0 was created for each ratio, allowing easier comparison across the different measures and industries.

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Table 1. SIC 2834, pharmaceutical preparations.

Cap/Book	Ratio	Index	Cap/Assets	Ratio	Index
Sepracor	29.46	6.71	Genentech	5.38	2.77
Genentech	8.39	1.91	Celgene	5.20	2.68
Celgene	6.55	1.49	Allergan	3.11	1.60
Allergan	5.44	1.24	Forest Labs	2.93	1.51
Lilly	5.18	1.18	Barr	2.41	1.24
Abbott	4.57	1.04	J&J	2.39	1.23
J&J	4.27	0.97	Sepracor	2.34	1.21
Bristol Myers Squibb	4.17	0.95	Lilly	2.04	1.05
Wyeth	3.92	0.89	Endo	2.02	1.04
Schering Plough	3.85	0.88	Abbott	1.98	1.02
Merck	3.83	0.87	Merck	1.73	0.89
Cephalon	3.73	0.85	Bristol Myers Squibb	1.72	0.89
Hospira	3.70	0.84	Schering Plough	1.66	0.86
Forest Labs	3.53	0.80	Hospira	1.60	0.82
Barr	3.36	0.77	Wyeth	1.53	0.79
Endo	2.79	0.64	Cephalon	1.38	0.71
Mylan	2.70	0.62	NBTY	1.31	0.68
Perrigo	2.59	0.59	Pfizer	1.23	0.63
Pfizer	2.25	0.51	Mylan	1.01	0.52
NBTY	2.22	0.51	King Pharm	0.96	0.49
Watson Pharm	1.52	0.35	Perrigo	0.95	0.49
King Pharm	1.45	0.33	Watson Pharm	0.83	0.43
Industry Mean	4.39		Industry Mean	1.94	
Revenue/Asset	0.65				

Table 2. SIC 6020, commercial banks.

Cap/Book	Ratio	Index	Cap/Assets	Ratio	Index
Northern Trust	2.82	1.75	Credicorp	0.25	1.79
Commerce Bancorp	2.57	1.60	BoNY Mellon	0.22	1.57
TCF Financial	2.36	1.47	US Bancorp	0.22	1.57
Bank of Nova Scotia	2.33	1.45	Commerce Bancshares	0.21	1.50
Royal Bank Canada	2.33	1.45	Northern Trust	0.20	1.43
State Street	2.32	1.44	Synovus	0.19	1.36
US Bancorp	2.32	1.44	City National	0.18	1.29
Credicorp	2.31	1.43	State Street	0.17	1.21
Commerce Bancshares	2.18	1.35	TCF Financial	0.17	1.21
Canadian Imperial	2.03	1.26	Wells Fargo	0.17	1.21
Wells Fargo	1.96	1.22	BOK Financial	0.16	1.14
Toronto Dominion	1.88	1.17	M&T Bank	0.16	1.14
BoNY Mellon	1.86	1.16	Union Bancal	0.16	1.14
Union Bancal	1.82	1.13	Associated Banc-Corp	0.15	1.07
BOK Financial	1.77	1.10	BB&T	0.15	1.07
Synovus	1.72	1.07	Commerce Bancorp	0.15	1.07
City National	1.69	1.05	PNC	0.15	1.07
Bank of Montreal	1.66	1.03	Wachovia	0.14	1.00
M&T Bank	1.51	0.94	Fifth Third Bancorp	0.13	0.93
BB&T	1.49	0.93	Marshall & Ilsley	0.13	0.93
National Canada	1.49	0.93	National City	0.13	0.93
Fifth Third Bancorp	1.38	0.86	Webster Financial	0.13	0.93
Associated Banc-Corp	1.37	0.85	Bank of Nova Scotia	0.11	0.79
PNC	1.35	0.84	Colonial Bancgroup	0.11	0.79
Wachovia	1.35	0.84	Comerica	0.11	0.79
National City	1.33	0.83	First Citizens	0.11	0.79
Webster Financial	1.31	0.81	Regions Financial	0.11	0.79
First Citizens	1.24	0.77	Royal Bank Canada	0.11	0.79
First Horizon	1.24	0.77	Suntrust	0.11	0.79
Marshall & Ilsley	1.23	0.76	Toronto Dominion	0.11	0.79
Colonial Bancgroup	1.22	0.76	Zion Bancorp	0.11	0.79
Comerica	1.19	0.74	Bank of America	0.10	0.71
Bank of America	1.16	0.72	First Horizon	0.10	0.71
Key Corp	1.15	0.71	Huntington Bancshares	0.10	0.71
Huntington Bancshares	1.14	0.71	Key Corp	0.10	0.71
JR Morgan Chase	1.13	0.70	JP Morgan Chase	0.09	0.64
Deutsche Bank	1.08	0.67	Bank of Montreal	0.08	0.57
Suntrust	1.07	0.66	Canadian Imperial	0.08	0.57
Zion Bancorp	1.06	0.66	National Canada	0.08	0.57
Popular	0.98	0.61	Popular	0.07	0.50
Laurentian	0.87	0.54	Laurentian	0.05	0.36
Regions Financial	0.86	0.53	First Bancorp	0.04	0.29
First Bancorp	0.55	0.34	Deutsche Bank	0.03	0.21
Industry Mean	1.61		Industry Mean	0.14	
Revenue/Asset	0.07				

Table 3. SIC 2911, petroleum refining.

Cap/Book	Ratio	Index	Cap/Assets	Ratio	Index
Imperial Oil	5.02	2.24	Imperial Oil	2.41	2.21
Suncor Energy	3.54	1.58	Suncor Energy	1.60	1.47
Holly	3.45	1.54	Frontier Oil	1.47	1.35
Exxon Mobil	3.38	1.51	Husky Energy	1.43	1.31

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Table 3. (*Continued*)

Cap/Book	Ratio	Index	Cap/Assets	Ratio	Index
Frontier Oil	3.10	1.38	Holly	1.27	1.17
Husky Energy	2.72	1.21	Murphy Oil	1.19	1.09
Alon US Energy	2.42	1.08	Exxon Mobil	1.17	1.07
Sunoco	2.41	1.08	Chevron	1.08	0.99
Murphy Oil	2.23	1.00	Calumet Specialty	1.02	0.94
CVR Energy	2.11	0.94	Petro Canada	0.93	0.85
Chevron	2.04	0.91	Hess	0.77	0.71
Hess	2.00	0.89	Marathon Oil	0.75	0.69
Calumet Specialty	1.98	0.88	Western Refining	0.68	0.62
Petro Canada	1.95	0.87	ConocoPhillips	0.66	0.61
Western Refining	1.67	0.75	Nustar Energy	0.66	0.61
Marathon Oil	1.63	0.73	Alon US Energy	0.65	0.60
Tesoro	1.47	0.66	Valero Energy	0.65	0.60
Valero Energy	1.43	0.64	Sunoco	0.63	0.58
ConocoPhillips	1.40	0.63	CVR Energy	0.58	0.53
Nustar Energy	1.27	0.57	Tesoro	0.58	0.53
Industry Mean	2.42		Industry Mean	1.09	
Revenue/Asset	1.93				

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4. Discussion

What do these results tell us? Let us specifically look at two aspects of the data, within the industries and then across the industries.

Within the industries, the key question is whether the different approaches yield different results. In terms of magnitude and spread, the data are actually very similar. The pharmaceutical results show a little more spread, with a greater range in the index score for the cap/asset ratio (2.77 to 0.43 versus 1.91 to 0.33 if the outlier is removed). But the other industries are fairly similar in this regard. Commercial banks show 1.75 to 0.34 versus 1.79 to 0.21. Petroleum refining has scores of 2.24 to 0.57 versus 2.21 to 0.53. Generally, this is a remarkably similar result.

Within the results, the company rankings are also fairly similar. The top firms are very much the same in all three industries, as are the bottom firms. In pharmaceuticals, 7 of the top 10 firms are identical, and the dissimilar firms are just outside of the top 10. In the bottom 10, it us 6 of 10 identical, but the bottom 6 are exactly the same firms. For commercial banks, it us more of a mixed bag, with only 5 of the top 10 begin the same and some of those firms showing markedly different rankings. At the bottom 7 of 10 are identical though the pattern again shows a little more variety than what we saw with pharmaceuticals. For the petroleum refiners, 7 of the top 10 are the same though again the missing firms can be far further down the list in the opposite ranking. At the bottom it is again 7 of 10 begin the same though the bottom 6 are identical once more. In general, there is broad agreement on firm rankings though some differences in the details. Those details are more pronounced with the asset-heavy banks where the overall results are more compacted than in the other industries.

One aspect of these results of particular interest is the outlier figure for Sepracor in the Cap/Book ratings for pharmaceutical firms. The 29.46 number is obviously much different than that of any other firm in the database, and it is not repeated in the Cap/Asset ratio for Sepracor. The difference is undoubtedly due to debt, as Sepracor seemingly borrowed heavily to create its physical assets. Although not a common result, the example shows dramatically how the difference between the two metrics can yield very different outcomes in a handful of instances. As the more "realistic" ratio appears to come from the Cap/Asset ratio, we see the first indication of why one measure may be more reliable than the other.

One final note about the intra-industry results is that they allow us to process the results in more detail if we can add facts about the industry or individual firms. In pharmaceuticals, for instance, we can identify the biotech firms (at the top) versus the generic manufacturers (near the bottom) versus the more traditional manufacturers (throughout the middle). This pattern is apparent according to both metrics and is as expected in terms of where more valuable knowledge is likely to reside. Similarly, within the petroleum refiners, we see large, vertically integrated firms like Exxon Mobil and Chevron that can be compared against firms principally in refining (near the

bottom) and/or heavily into transportation and logistics (i.e. pipelines). Those in logistics and/or with some investment in reserves will have a different profile than those in a fairly mature industry like pure refining. All this provides motivation for deeper evaluations of such industries to achieve a further understanding of the IC dynamics, but the key point is that both metrics provide evidence allowing such additional analysis.

Across industries, the picture is fairly clear. One of the principal reasons to do this type of analysis is to identify industries in which KM is a more critical issue, where aggressive development of knowledge is necessary to keep up with the rest of the industry. In that case, a high score on whatever metric is used would indicate an industry where such an imperative exists. If a firm cannot keep up with average knowledge development in the industry (or do a superior job to gain competitive advantage), it will not be competitive. Both metrics appear to do a reliable job in assessing knowledge development.

In pharmaceuticals, where we expect high levels of human capital in R&D and manufacturing as well as high relational capital in marketing/sales and in interchanges with regulators, the knowledge mandate in the industry should be high. And, by both metrics, the pharmaceutical industry is indeed considerably above the other industries. Commercial banking, on the other hand, with a high degree of operational regulation, little innovation, and not much new whatsoever, the level of intangible assets is predictably low. Again, both measures are in agreement on that. Refining, with everything from old-line refining to investments in knowledge-heavy renewable energy, lands somewhere in the middle. Again, one can delve more deeply into the reasons behind the KM ratings, but they are very consistent in the results, giving us good reason to trust both metrics. Further, because they generally support one another, it gives us further confidence in using either one individually. All in all, both versions of Tobin's q appear acceptable for the purposes intended. The Cap/Asset ratio appears, both logically and in terms of the possibility of outliers due to debt loads, somewhat superior but not by a wide margin.

5. Conclusions

This study examines metrics on knowledge development at the firm level allowing comparisons across firms and across industries. Built on publicly reported financial documents, the data used are objective and readily available. Further, they are capable of indicating industries in which substantial IC is necessary to compete (or not) as well as relative standing of firms' IC holdings within such industries. As such, these metrics can help practitioners determine the necessary level of investment in KM programs and scholars determine how the same KM impacts competitiveness. With such data, we can all begin to develop a better understanding of the strategy of KM, when and how to invest in developing knowledge.

The metrics compared here have a long history in the literature and are particularly useful precisely because of their availability and easy processing. Tobin's q generally has to do with the value of the firm (market capitalisation) compared with the value of its assets. Here, we have compared the ratio of market cap to book value of assets (assets less liabilities) and the ratio of market cap to asset value. The former brings debt into the discussion, so if available assets are largely borrowed, as with the commercial banks and their depositors, the book value will be lower.

The results demonstrate that the metrics are very similar across three disparate industries, pharmaceuticals, commercial banks and petroleum refining. Industries are easily comparable for their level of knowledge development, and the firms that are more or less successful compared to the industry average are consistent across both measures. The Cap/Book value shows the potential for outlier values because of high debt levels, a problem for a researcher who might not recognise such a possible biasing factor. But, otherwise, both measures appear to be valid and reliable for our purposes.

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